



A Real Time Communication Protocol for the Virtual Missile Range

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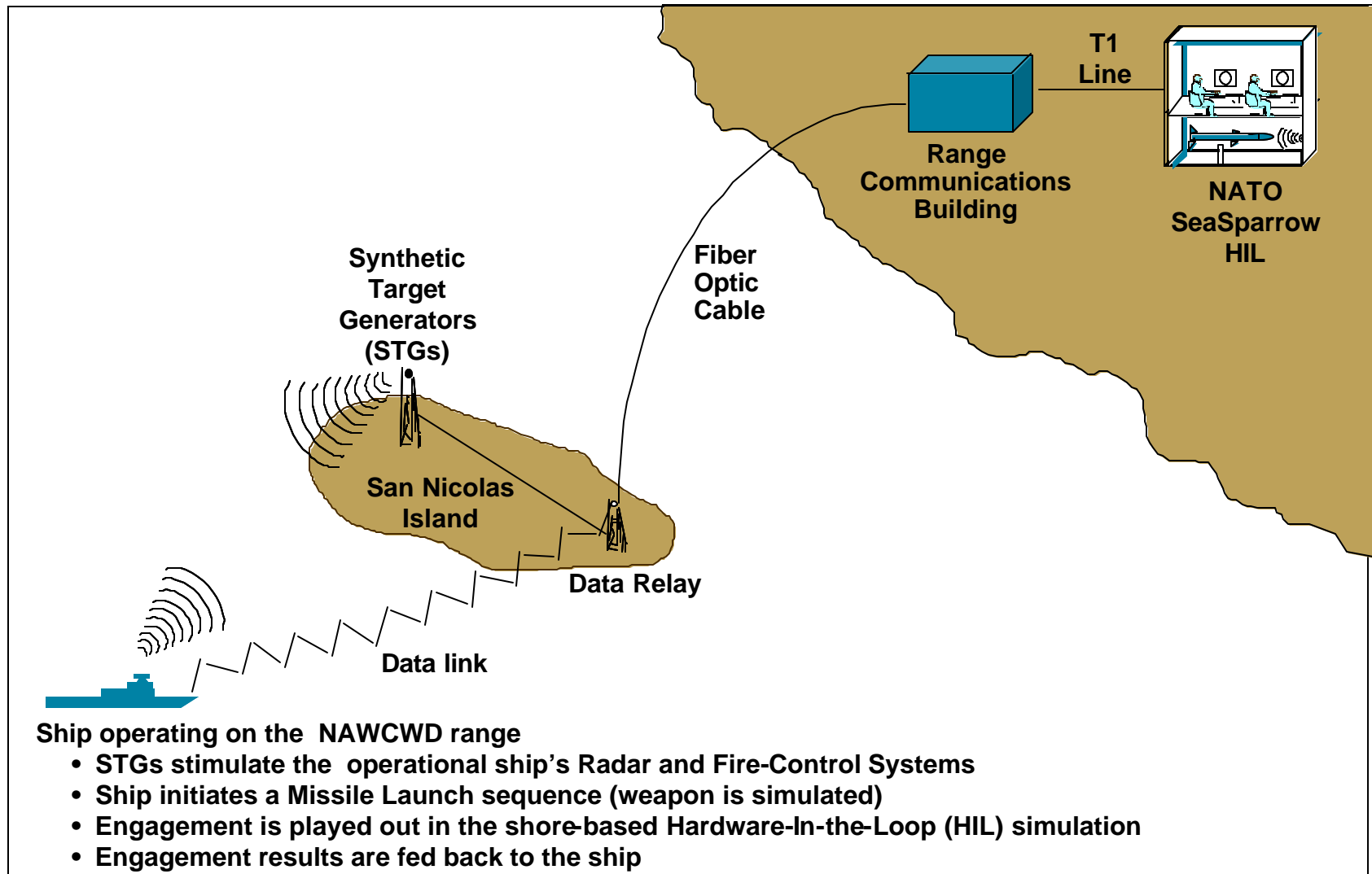
Virtual Missile Range (VMR)

- **Shortfall of target and missile allocations for training and test and evaluation are impacting readiness, budget and schedules**
- **VMR Purpose: Provide a low cost supplement to live fire exercises for test and evaluation and training**
- **Initial Implementation: SeaSparrow missile system, Spruance-class destroyers, NAWCWD Sea Range**
- **Expandable to include a variety of weapons, threats, and platforms**

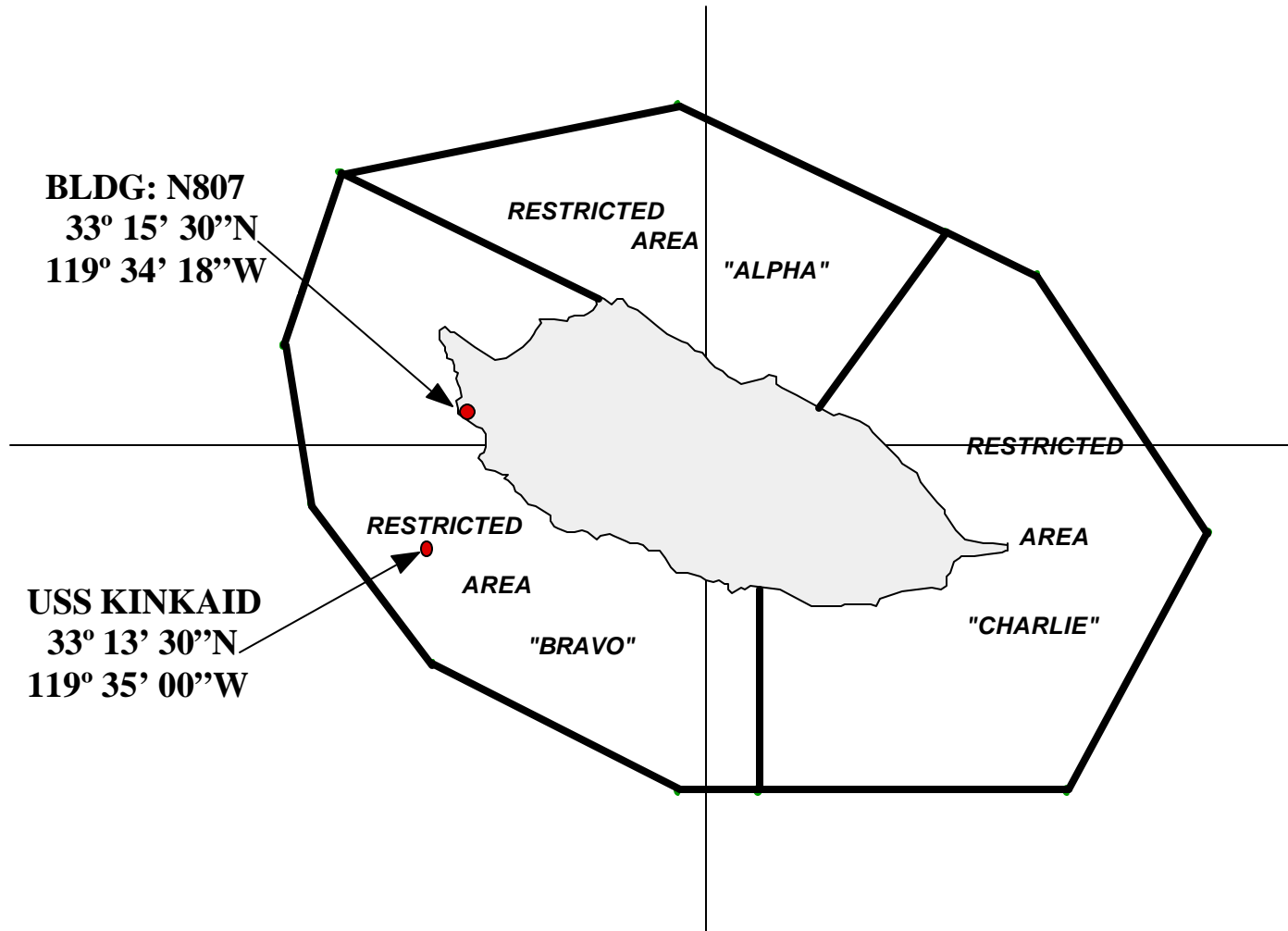
NATO SeaSparrow Missile System



VMR Operational Configuration



VMR Location Near San Nicolas Island



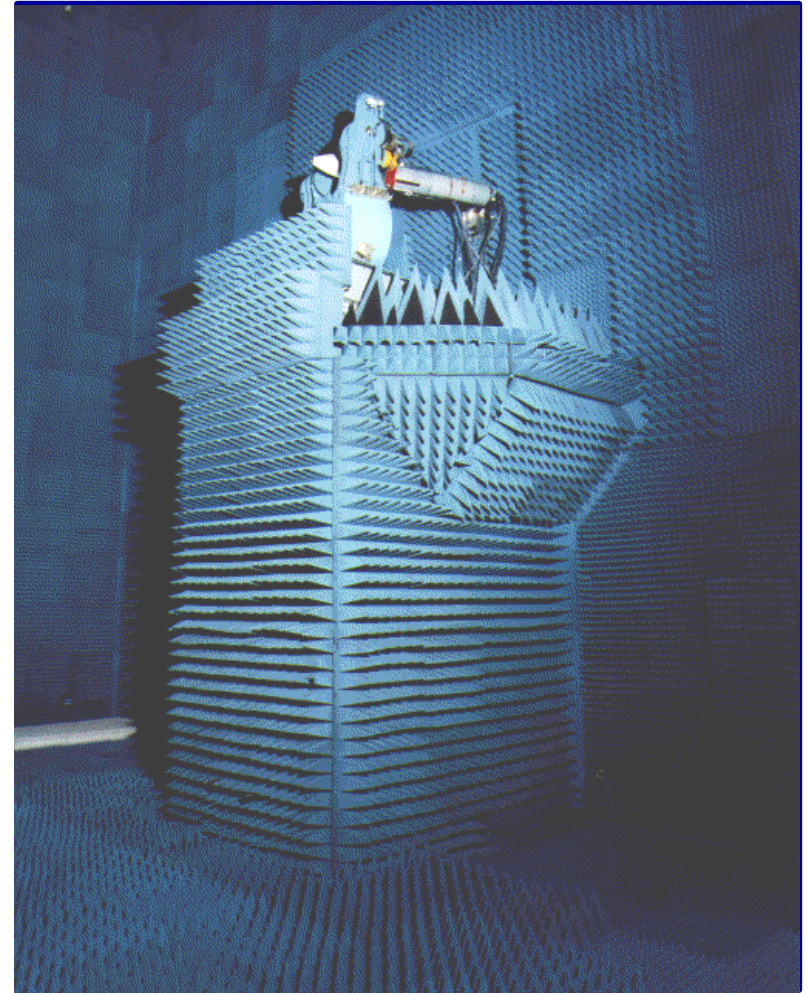
ESSM/Sparrow Hardware-in-the-Loop (HIL) Laboratory

- **Major Components**

- Missile guidance system on a 3-axis motion table
- Anechoic chamber with 48-horn target array
- High performance, real-time computer system

- **RF Signals Simulate**

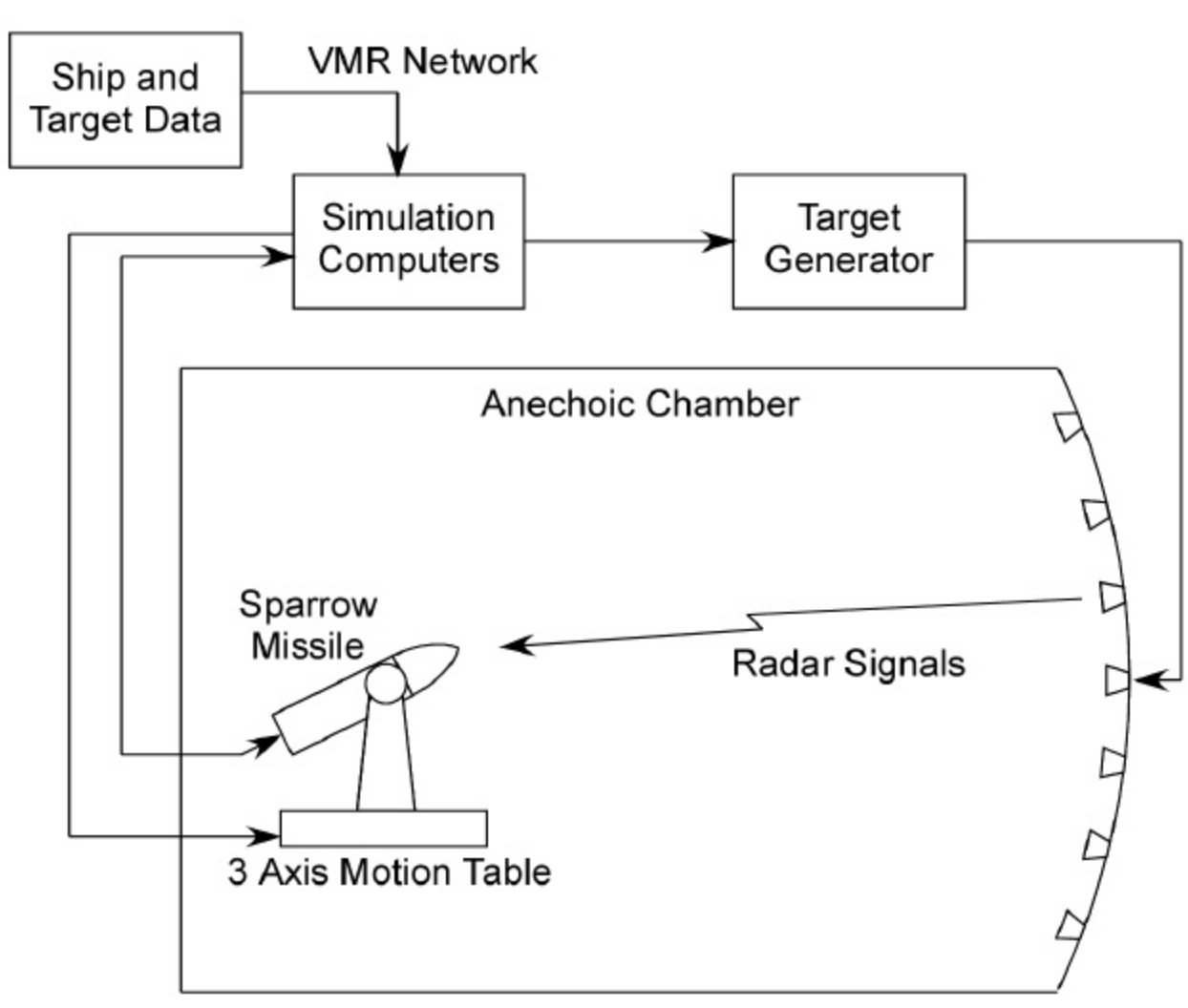
- Target skin returns
- Sea clutter
- Sea image
- Electronic Countermeasures



ESSM/Sparrow HIL Laboratory

- **High fidelity NATO SeaSparrow Simulation**
- **Exercises missile seeker and guidance hardware and tactical software from pre-launch through intercept**
- **Currently used for RIM-7P DT/OT and ESSM DT support (average 10,000 shots per year)**
- **Provides missile system evaluation including end-game**
- **Receives pre-launch umbilical signals from the shipboard fire control system**

ESSM/Sparrow HIL Laboratory



VMR Network Performance Requirements

- **SeaSparrow is a highly dynamic missile**
- **Launch sequence timing must be accurate**
- **Network latency may have negative impact on validity of simulation results**
- **This concern drives a requirement for the maximum acceptable latency**
- **Latency requirement: No more than 10 milliseconds one-way latency in Ship-HIL and Target Generator-HIL paths**

HLA Performance Testing

- **Early versions of HLA (in 1997) were tested for real time latency performance**
- **Testing has continued with more recent versions**
- **Latest version tested: RTI-NG 1.3v3.2**
- **Recent test tool: BmLatency benchmark**
- **Test platform: 400 MHz Pentium II, NT4**
- **Latency test results: Min: 10 mS, Mean: 10.09 mS, Max: 20 mS**

Real Time Simulation Protocol

- **HLA performance was (and remains) unacceptable for VMR**
- **A new protocol was developed: The Real Time Simulation Protocol (RTSP)**
- **RTSP Features:**
 - UDP Multicast for bandwidth efficiency
 - Efficient runtime operation
 - Platform independence (byte-ordering and structure packing issues automatically handled)
 - Easy to use
 - Possible to use in conjunction with HLA RTI

RTSP Elements

- **Message Definition Format (MDF) file**
 - Completely defines simulation message traffic
- **MDF Translator program**
 - Parses the MDF file and generates C++ code
- **RTSP runtime software**
 - C++ code performs network communication and other functions
- **Controller application**
 - Controls operation of distributed simulation

Message Definition Format

- **MDF is a text file format for specifying the federates and messages used in a distributed simulation**
- **UDP Multicast parameters such as IP addresses and port numbers, and time-to-live can be specified in the MDF file**
- **Each federate is declared and given a name**

VMR MDF File (Part I)

```
// VMR Federation Message Definition, Version 1.2
// Jim Ledin                                27 Apr 1999

// Define the base IP address and port for multicast groups.
multicast_base_addr = 225.0.0.0;
multicast_base_port = 12000;

// Declare names for all federates and array sizes, if any:
federate Ship, Missile, Target, Viewer;

// Define a federate state structure for use in multiple messages
struct State
{
    double latitude;    // Deg. North
    double longitude;   // Deg. East
    float  altitude;    // Feet above MSL
    float  vel[3];       // Feet/Sec, 0=North, 1=East, 2=Down; Earth-relative
    float  euler[3];     // Deg. 0 = Roll (+CW looking fwd),
                        //      1 = Pitch(+nose up),
                        //      2 = Yaw(+East of true North)
};
```

VMR MDF File (Part II)

```
// Ship update message
message Ship.Update
{
    State state;
    float launcher_az; // Deg., Azimuth +right of fwd, deck-relative
    float launcher_el; // Deg., Elevation +up from horizontal, deck-relative
    float illum_az;     // Deg., Azimuth +right of fwd, deck-relative
    float illum_el;     // Deg., Elevation +up from horizontal, deck-relative
    uchar illum_on;     // 1 = illuminator is on, 0 = not on
};

// The Ship gets the missile umbilical data and updates from all Targets
subscribe Ship : Missile.Umbilical, Target.Update;

// The Missile gets the umbilical data and updates from Ship and Targets
subscribe Missile : Ship.Umbilical, Ship.Update, Target.Update;

// The Targets get the Ship updates and the kill indication from the missile
subscribe Target : Ship.Update, Missile.EndOfRun;

// The Viewer gets all messages sent by all federates
subscribe Viewer : *.*;
```

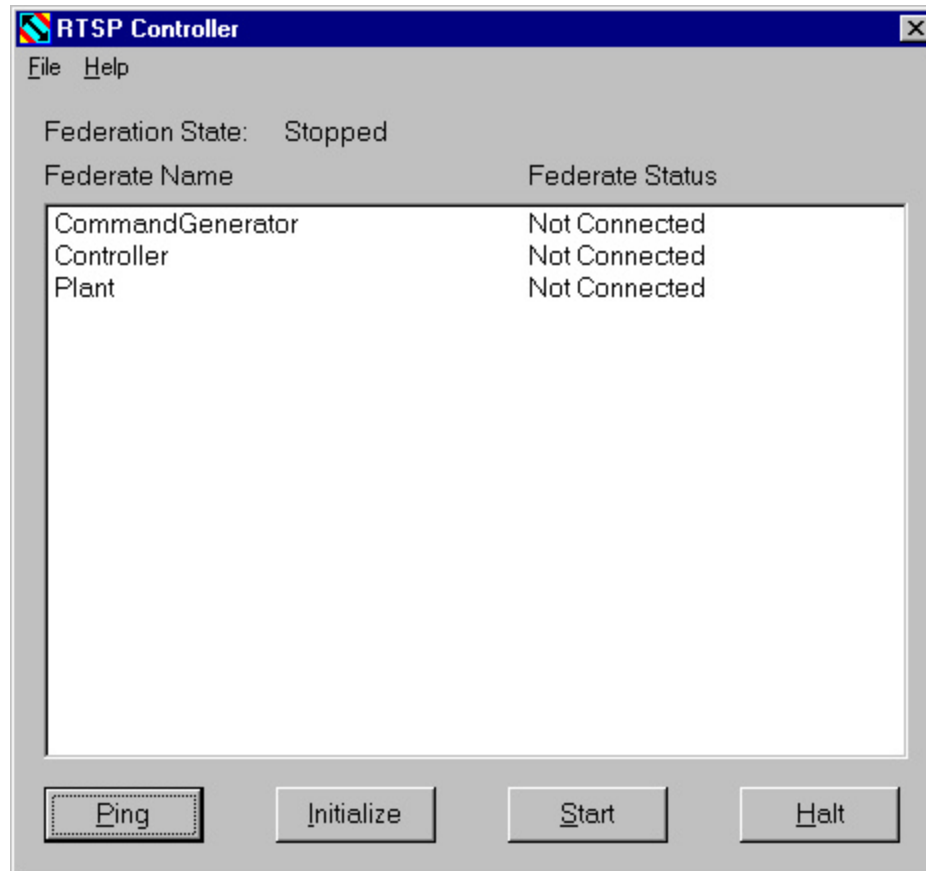
MDF Translator Program

- **The MDF Translator reads an MDF file and creates a set of C++ class header files**
- **These classes provide the interface for sending and receiving the messages defined in the MDF file**
- **Each simulation must be compiled with the appropriate class header files and the RTSP runtime software module**

RTSP Runtime Software

- The RTSP runtime software is contained in the file RTSP.cpp
- This software provides network communication for the C++ classes generated from the MDF file
- The RTSP software is portable between Windows NT, Unix (Solaris), and VxWorks

Controller Application



RTSP Performance

- The use of UDP Multicast allows one message to go to many recipients
- Polling can be avoided by using callbacks
- Processing of incoming and outgoing messages is exceptionally efficient
- Latency: Min: 0.05 mS; Mean: 0.1 mS; Max: 0.25 mS
- RTSP is 10 to 100 times faster than HLA RTI

Summary

- **Missile simulation in VMR requires a high performance network communication protocol**
- **HLA RTI performance remains inadequate**
- **The Real Time Simulation Protocol meets the VMR performance requirements and is easy to use**